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It is sometimes desirable to obtain a normal mode solution of a wave-guide problem in a closed mathematical form. In particular, here, the vertical part of the solution in terms of a sine series for a variable velocity profile where the sine functions are eigenvalues for a suitable isovelocity case is desired. This problem has been done within the context of conventional perturbation theory as was found to be too limiting, particularly for the lower-order modes. It is possible, however, to exploit Sturm-Liouville theory and closure to obtain a coupled system of equations that leads to an adequate sine expansion as well as the appropriate eigenvalues. A new perturbation method is also derived from the results that is less limiting than the conventional perturbation approach and should be of general value to other classes of problems. Calculations are performed and compared with other numerical techniques.

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